ABSTRACT

The delivery of civil engineering projects requires civil engineers to address a broad spectrum of issues generated by both project participants and regulatory agencies. Providing tools that assist team members in addressing these issues through the use of information and knowledge from previous projects may reduce project errors by creating informed decision-makers. Recent advances in communications and computer technologies provide the opportunity to enhance student access to these resources. The Civil Engineering Resource Library research effort explores this opportunity by combining an introduction to civil engineering processes with emerging Web-based technologies. This combination is captured in an electronic library that uses case studies to illustrate emerging civil engineering practices and regulatory compliance strategies.

INTRODUCTION

The lifecycle of civil engineering projects incorporates a broad and diverse set of design and construction issues. From initial project development through construction and operations, civil engineers address a broad spectrum of requirements established by direct constituents including the owner and the design team and indirect constituents including regulatory agencies and jurisdictional governments. The combination of aesthetic, engineering, and regulatory issues creates a diverse, and often conflicting, set of demands that result in each project appearing to be a one-of-a-kind endeavor. While this diversity reduces the opportunity for civil engineers to apply previous project solutions directly, diversity increases the need to provide documentation and storage tools that enable civil engineers to learn and extrapolate from previous solutions. Specifically, tools that provide team members with information and knowledge from previous projects can assist in reducing project errors by creating informed decision-makers. For example, the consistency of external issues such as wetland regulations over extended periods of time provides an opportunity to establish information libraries that highlight project solutions and compliance strategies. This opportunity is the basis for the Civil Engineering Resource Library, an electronic case library for civil engineering students.

The Resource Library research effort integrates computer technologies into the classroom to augment traditional documentation and learning techniques. Specifically, the research effort combines an introduction to civil engineering processes with emerging Web-based technologies to create an electronic library that uses case studies to illustrate emerging civil engineering practices and regulatory compliance strategies. This paper introduces the research effort as it developed through classroom and industry analysis, field studies, and an initial CD-ROM-based prototype.
Figure 1: The Civil Engineering Resource Library structure focuses upon the use of hierarchical indexing and links to organize individual elements including video, drawings, and documents.

**RESOURCE LIBRARY DEVELOPMENT**

The Civil Engineering Resource Library has followed a development path leading from the classroom to the professional office, and finally, to the computer lab. From the outset, the Resource Library research focused on understanding the environments where the electronic library concept would enhance learning and the production of project solutions. As such, a series of steps were established for the research effort as follows:

1) Develop a course to interactively obtain both student and educator perspectives on the information required to present civil engineering cases, processes, and solutions;

2) Establish a test program within a professional office to determine areas of professional interest and focus;

3) Perform field studies of particular cases to establish a baseline set of structured library entries on which to expand the Resource Library; and

3) Develop a technical solution for an electronic library incorporating a structured, but flexible, environment that addresses the requirements of multiple constituents.
In approaching the prototype development effort, two requirements guided the overall concept; (1) the solution must provide an easy to use supplement to the classroom and professional environments, and (2) the solution must be generic and robust to allow additional case studies to be added on a constant basis. The first requirement specifies two important concepts, ease of use and a focus on supplementary information. In terms of ease-of-use, it must be acknowledged that if it takes longer to determine how to retrieve information from an electronic system than it takes to retrieve the information by manual means, then the value of the system must be questioned. In terms of a supplementary focus, the Resource Library is intended to supplement, not replace teachers or senior professionals in the classroom and the office. Thus, providing examples and explanations that build upon first principles are more important than attempting to electronically explain fundamental engineering concepts. The second guiding requirement specifies that the system be extensible in terms of content and examples. Given the unique attributes of each civil engineering project, a series of case studies are required to sufficiently address the diversity of issues emerging in civil engineering.

Although today’s computing technologies provide a range of viable alternatives, the pervasiveness and rapid expansion of the World Wide Web set this platform apart from the remaining options and made it an obvious choice for prototype deployment. Given this selection, a modular approach was developed that emphasized a hierarchical structure with the flexibility for expansion at many levels. As illustrated in figure 1, the hierarchical structure within the Resource Library begins at the Element Level with individual elements such as documents, images, and video clips. Each of these elements is linked to a Resource Library entry at the Entries Level. Similar to traditional library catalogs, Resource Library entries provide the search and access points for the individual elements. Each entry
contains a description of the linked element and a set of keywords that indicate the case from which the entry was
developed, and if applicable, materials, processes, and equipment that are spotlighted in the element (Figure 2).
These keywords provide the links to the central organizing component within the Resource Library, the Modules
Level. Modules organize categories of case entries, equipment types, construction processes, and material examples
into structured groupings (Figure 3). Through these modules, additional cases and examples can be integrated into
the Resource Library with a common look-and-feel interface, but without disrupting existing entries or links. The
Resource Library modules are defined as follows:

- Cases – A comprehensive collection of documents and video clips covering individual projects through
  the project life cycle.
- Processes - A collection of indexed entries following CSI format that illustrate the steps, applications,
  and variations associated with common construction processes.
- Equipment – A collection of indexed entries that illustrate common and unusual uses of construction
  equipment such as graders and tractors.
- Materials – A collection of indexed entries that showcase the use and installation of common
  construction materials including cast-in-place and pre-cast concrete.

Figure 3: Resource Library modules provide a central organization structure for all entries
contained within the library.
Figure 4: An individual entry chronicling the foundation excavation of a case is cross-indexed to indicate the existence of relevant excavation equipment and process information within the video clip.

The Resource Library Modules

Based on the premise that an electronic library should complement, and not replace, classroom or professional education, the Resource Library modules are designed to serve multiple constituencies. For courses focusing on specific topics such as construction operations, the Processes module may be used to highlight individual operations without the requirement for extensive project context to accompany the illustrations. Similarly, in a course focusing on a specific topic such as environmentally conscious design and construction, the Cases module may be used during a series of lectures to provide students with a continuous, in-depth example of how a specific project addressed the course topic.

For courses focusing on a broader level, the modules may be used to provide overviews of different topics. For example, the Cases module could be used to provide examples of overall project strategies that have been employed to address situations such as wetland development, design for disassembly, and infrastructure rehabilitation. Similarly, the Equipment and Processes modules could be used to provide a set of examples of standard and non-standard
solutions to commonly encountered construction operations. For example, the Processes module contains several examples of solutions to drainage problems during construction operations. The combination of successful and unsuccessful solutions demonstrates that a number of approaches are available but incorrect procedures can result in erosion and silt problems. In this manner, the Resource Library builds upon cases to provide multiple viewpoints of each document.

The decision to include these multiple viewpoints presented the potential problem that a significantly greater number of entries could be required within the library. To address this problem, a design approach was adopted that emphasizes case studies as the core of the repository. Based on the field study approach adopted early in the research effort, combined with the large body of evidence stating that case histories are a valuable addition to the learning environment (Fitzgerald 1995; Smith and Kardos 1990), case studies were established as the organizing structure for all stored materials. Specifically, all Resource Library entries are initially developed as part of a chronological description of a specific case. After creating this chronological history, individual video clips are evaluated for possible cross-indexing in the remaining Resource Library modules. For example, the entry illustrated in Figure 4 focuses upon the excavation of a foundation footing at the Stone Mountain Tennis Center. While this entry was initially selected to be an entry within the Stone Mountain case study, it was subsequently cross-listed in the Processes module as an example of an excavation operation and in the Equipment module as an example of an excavator. In a similar manner, each of the 5 case studies initially selected from the 1996 Olympic Games development effort were analyzed for potential use in multiple modules. Through this cross-listing approach, the Resource Library maximizes the use of entries while addressing the user need for both broad, contextual viewing of multiple entries and specific, directed viewing of individual entries.

**Resource Library Navigation**

The use of the modular approach within the Resource Library prototype provides users with an easily navigable environment to explore the library entries and civil engineering topics. Based on the four modules, a user may either take a sequential or direct approach to viewing the Library entries. In the sequential mode, a user may obtain an overview of specific approaches to a civil engineering topic by proceeding chronologically through an individual case. From early regulatory documents to final project completion, each step of project development is divided into chronological segments. By sequentially proceeding through these sections, the user obtains an introduction to the project at a rate that is compatible with their personal learning style. In contrast to the traditional learning environment where every student is required to proceed at the pace set by the instructor, this approach acknowledges that each student works at a different pace and encourages the student to spend the time required to obtain an understanding of a given topic.

Complementing this sequential access mode, is the ability for users to obtain specific pieces of information or knowledge through a direct access format. The inherent capability within Web documents to provide users with hypertext capabilities serves as the basis for this access approach. The interconnected Resource Library entries provide users with a flexible navigation capability that responds to individual information requirements. For example, a professional who starts navigating the system in the Processes module may find that a pre-cast concrete entry is of particular interest. At this point, the professional may elect to follow a hyperlink to the Cases module where contextual information is located that describes the background and selection process for the particular pre-cast installation approach. Through this directed information access, each user has the capability to develop an individual knowledge retrieval strategy.

**Combination of Media**

The use of hyperlinks and Web-based entries is not a unique endeavor at this point in time (Collis, et.al. 1997; De Bra 1997). However, the Resource Library prototype represents a progression in this field based on its unique use of
diverse media within a civil engineering case repository. In developing the Resource Library modules, diverse media has been combined including text written by the researchers, Federal and COE regulatory text, illustrations and photographs, PowerPoint slide shows, and QuickTime video sequences from individual cases. When used separately, each of these media types can be an effective tool to illustrate concepts, terminology, and core ideas. This usage is seen repeatedly in textbooks, slide shows, and documentary footage describing notable case studies. However, when combined, these individual media elements can be used to present an informational context that is both thought-provoking and stimulating.

The Resource Library prototype introduces this combination of media throughout the project. For example, when introducing the concept of design for disassembly, the prototype brings together several media components within a single consolidated concept. First, research reports are used to introduce the core concepts behind the evolution of this design and construction concept. Second, to provide a further understanding of the topic as it applies to the Georgia Tech Water Polo facility, the case is linked to project drawings illustrating the assembly and disassembly project phases. Finally, to illustrate the application of the concept, the Resource Library entries incorporate textual descriptions and video clips documenting the use of disassembly technologies within the Water Polo venue. By combining these elements into a single resource context, the prototype introduces civil engineering concepts through a series of layers progressing from the general to the specific.

In this layered concept, a context is established that encourages exploration and self-discovery. In contrast to a classroom, continuing education, or standard office setting where topics are introduced through a single lecture or article, the Resource Library provides the opportunity to continue the knowledge acquisition process by accessing additional library entries. As in the Water Polo example, the professional is provided the opportunity to proceed through multiple layers of disassembly information, each of which becomes progressively more specific and in-depth. This delayering of a topic is intended to stimulate the user to pursue the knowledge acquisition process while avoiding the trap of overwhelming the user with an abundance of information in a single session. In this way, the retention of the material may be enhanced since each layer of the topic progressively reinforces the previous layer by building upon existing knowledge and information (Minsky 1986).

**CONCLUSION**

The development of the Resource Library prototype represents the first stage in the introduction of multimedia case repositories into the civil engineering classroom. Although the repository takes advantage of emerging video, document, and Web technologies, the repository remains an educational resource based on minimally assessed technologies. The successful introduction of an education technology requires developers to answer questions beyond just technical issues. The assessment of such technologies is one such question. Are multimedia technologies enhancing the education process? Can the technologies replace some lecture materials? Are students retaining the information to greater or lesser degrees than traditional lecture and lab formats? Each of these questions must be answered to fully understand the impact of multimedia technologies in the classroom. Unfortunately, the majority of work and effort currently seen in the education arena tends to be focused more on tool development than tool assessment.

In an effort to break from this pattern, the author is entering an assessment phase for the Resource Library. This assessment effort will focus on two components: an internal evaluation across several Georgia Tech courses, and an external evaluation based on the introduction of the resource in external universities. Currently, 15 universities are testing the Resource Library in structural design and construction courses at both undergraduate and graduate levels. Initial results from these efforts are anticipated in the summer of 1999. The results of these studies will be used to create a second version of the library that will be made available on the World Wide Web.
REFERENCES


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